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AUTOMATIC PHOTOINTERPRETATION FOR LAND USE MANAGEMENT IN MINNESOTA

ERTS

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Summary

Progress is being made in the areas of sun angle and atmospheric effects on the data and its interpretation. The effort is aimed at correction using only navigation and calendar data needed for satellite operation and derivations from the MSS data.

Water estimation of value to land planners and conservationists has been demonstrated with verification of performance by comparison with a concurrent study involving map planimetry, aerial photos, and field-checking. The satellite will provide seasonal and annual coverage with timely information in a way not now feasible by conventional methods. For example, the reference data were obtained using the most recent files, which date back to 1949, and from most recent photography taken in 1968. The calendar time involved was three to four months, which is a reflection on priority pressure on trained manpower available. ERTS data can help relieve this problem by providing the needed information while freeing trained manpower for more appropriate parts of the effort.

DETERMINATION OF LAND USE IN MINNESOTA BY AUTOMATIC INTERPRETATION OF ERTS MSS DATA

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INTRODUCTION

The aim of this program is to determine the feasibility of identifying land use in Minnesota by automatic interpretation of ERTS-MSS data. Ultimate objectives include establishment of land use delineation and quantification by computer processing with a minimum of human operator interaction. This implies not only that reflectivity as a function of calendar time can be catalogued effectively, but also that the effects of uncontrolled variables can be identified and compensated. Clouds are the major uncontrollable data pollutant, so part of our initial effort is devoted to determining their effect and the construction of a model to help correct or justifiably ignore affected data.

Other short range objectives are to identify and verify measurements giving results of importance to land managers. Lake-counting is a prominent example. Open water is easily detected in Band 7 data with some support from either Band 4 or Band 5 to remove ambiguities. Land managers and conservationists commission studies periodically to measure water bodies and total water count within specified areas.

We performed a lake count in Ramsey County and compared the ERTS-derived count with a concurrent University of Minnesota aerial photo planimetry count. The results were usually within 10 percent on individual water bodies. Consideration of reasons for the discrepancies indicates that the ERTS method should be used as the comparison reference. The feasibility of water estimation using ERTS data is established, the extension to implementation is straightforward, and at least one worker used to the frustrations and tedium of conventional methods is impressed.

ATMOSPHERIC EFFECTS STUDY

Reflectivity of terrain is the basis for multispectral (color) discrimination to determine land use, vegetation species and stress, water quality, etc. The multispectral scanner collects reflected sun irradiation in the visible and near infrared. Additive components contributing to the MSS output include both useful terrain reflection and useless atmospheric scatter. The terrain reflects both direct sunlight and downscattered skylight in quantities and relative proportions dependent on sun angle, local and general atmospheric conditions, and wavelength.

A cursory glance at almost any ERTS photograph shows the wide variety of situations which can occur and the futility of trying to characterize the atmosphere by an average number or by single point measurements. Throughout a 100 by 100 nmi format the clouds vary widely in density, size, shape, orientation and position. No particular situation ever repeats. A fascinating continuum exists between the extremes of no-cloud and dense cloud. The ground can be seen through tenuous cloud, and various densities of cloud shadow are cast. One question of interest is the degree of cloud allowable which will still permit land use categorization.

The ultimate data processor requirements will be shaped partly by desirability and partly on feasibility. We anticipate a need for cloud and cloud effect detection, and for data correction based on sun angle, season, and atmospheric conditions. It is assumed that inputs such as sun angle and geographic location will be available, but that atmospheric corrections should be derived from MSS data as simply as possible. Point-by-point or small-area correction is needed to reduce data storage requirements on-line because major disturbances such as cloud shadows occur in the data stream before the clouds.

Our efforts to date have included construction of a computer simulation to compute the expected apparent radiance of large easily identified surface objects for which the spectral reflectivity is reasonably well-known. Computation of the expected intrinsic radiance due to direct sun illumination is straightforward. However, the skylight component in a given situation is not so well known, and the contribution due to atmospheric scattering toward the MSS is not known. To estimate the effects, MSS data for large water bodies, for cloud shadowed terrain are used, and for dense clouds are used.

Dense, powder-pull clouds casting recognizable shadows provide one way to estimate the proportion of indirect illumination when the shadows fall on identifiable homogeneous terrain. Thus, we are comparing the appearance in MSS data of band values in and out of cloud shadows at various sun angles with the computational model.

The insertion of tenuous cloud, visible or not, changes the spectral illumination and appearance of the terrain, as well as the radiance levels. The "color diagram" coordinates of the source shift, the reflectivity of the terrain shifts, and the observed radiance coordinates move toward the source as the cloud density increases. Large bodies of water provide the most stable large area reflector, so we are using data from the Red Lakes, Lake Superior, et al, in the Minnesota area to derive correction factors. This effort supplements the forest species and land management computer classification described in a companion paper by Kirvida, et al. The classifier derived therein pertains to a small area at one time under favorable atmospheric circumstances. This work is aimed at extending the classifier to varying calendar, atmospheric and geographic conditions.

RAMSEY COUNTY LAKE STUDY

This study compares the determination of lake acreage from ERTS data with that from conventional means. The relatively low radiance values of water in ERTS Band 7 give initial geographic orientation in pilot run printouts (rivers, lakes, ponds). Lines drawn around clusters of values in the count range 0 to 5 correspond reasonably well with the map or photo locations, shapes and relative sizes. By chance a University of Minnesota graduate student was performing a planimetry survey for the Minnesota Land Management Information System at the time we received MSS tapes.

Each MSS data point corresponds nominally to about 1.5 ground acres. To account for element overlap along the scan lines, the expression $1.104N + .453L$ converts the number of elements to acres, where N is the number of elements and L is the number of scan lines involved. The signal level range 0 to 5 is arbitrary, and subsequent analysis indicates that 0 to 3 might be better. However, the results given here are for the initial 0 to 5 range, which appears adequate to discriminate open water from marsh.

Table 1 shows results for 16 of 72 map designated water areas or basins. These 16 are "fish" or "marginal-fish" lakes for which planimetry results were available. The discrepancies in apparent area vary from less than one percent to 42 percent, with seven less than 10 percent.

In comparing figures it must be remembered that the lake area includes most marsh areas around the lake, and not just the areas of open water. However, the MSS Band 7 levels appear to indicate only open water, or water with small amounts of emergent vegetation or rushes.

Results on the remaining 56 lakes indicate that the ERTS data more accurately reflect the current water orientation than do the old map data. Aerial photographs have shown that many lakes on the map have been subsequently eliminated by drainage (some map information dates back to 1949).

Water areas not designated as lakes were found in the ERTS data. These corresponded to areas of water or swamp on USGS topographic maps. Since the appearance of water appears detectable, water fluctuation in a swamp area of known contour could be used to estimate the water table variation. This information, when combined with other information dealing with inflow and outflow from a lake by surface systems would enable the determination of mass budgets for lakes.

Table I. Ramsey County Fish Lake Survey

LAKE		ACREAGE		RATIO
No.	Name	ERTS-DERIVED	MAP PLANIMETRY	PLAN./ERTS
62-1	Silver	59	73	1.23
7	Gervais	204	206	1.01
13	Phalen	191	192	1.01
28	Sucker	55	60	1.08
39	Twin	25	35	1.42
46	Pleasant	551	627	1.14
54	McCarran	62	70	1.12
55	Como	63	72	1.14
56	Owasso	332	355	1.07
57	Josephine	112	115	1.03
61	Turtle	416	447	1.07
71	Valentine	50	60	1.19
73	Snail	138	185	1.34
78	Johanna	189	225	1.19
62-82	Wabasso	37	46	1.25
82-167	White Bear	2367	2479	1.05
16 lakes	Sums	4851	5247	1.08

One of the most important lake types in Minnesota is that in which ducks breed. These lakes are usually small and periodic, appearing in the spring and summer as lakes, but as swamps and dry spaces the rest of the year. The importance of these lakes is often not realized in time to prevent farmers from draining them. Location of these lakes by ERTS monitoring could help preserve these areas and the Minnesota duck population.